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Formaldehyde is an intermediate chemical compound used mostly for polymers – especially glues. Formaldehyde is produced from natural gas using steam reforming and methanol as an intermediate product. In this work, the objective was to design a formaldehyde plant to produce 115,000 ton/year by employing a systematic design procedure consisting of twelve hierarchical tasks. Process optimization, heat integration and environmental impact analysis are also considered in obtaining the final design.

The process itself consists of three parts, the natural gas steam reforming to syngas, the methanol synthesis and the formaldehyde synthesis. After the methanol synthesis, the unreacted syngas is recycled back, and the methanol is separated from the remaining compounds by distillation and it is fed to the formaldehyde reactor. After the formaldehyde synthesis, water is added in an absorber to stabilize the formaldehyde and create formalin. Formaldehyde is present in water as methylene glycol. Methanol is separated from the product by distillation and recycled to the reactor.

Once the base case design is obtained, an economic evaluation is performed in order to identify process bottlenecks. To improve the base case design, optimization and heat integration were performed which resulted in more than 50% reduction in process utilities (energy and water).

To further improve the design, sustainability and LCA analysis were performed to identify the hotspots of the process and subsequently to reduce the environmental effects of the plant. It was found that utilizing purge gas as furnace fuel for the reactors or alternatively if CO_2 is available from a nearby plant, an increased amount of hydrogen can be converted in the methanol synthesis step. The final design had lowered the operational cost and the process became more sustainable. The final design of the production of formaldehyde is an economically viable and a more sustainable process.